Nokia Networks

Enhanced Cell_FACH raises operator revenue-generating potential

Deliver HSPA+ services with lower latency, faster call set up and longer device battery life

Contents

1. Executive Summary

As smartphones have evolved, so has HSPA, bringing many enhancements that boost network capacity and the customer experience. Smartphones transmit small data packets frequently, caused by the background activity of the operating system, the related network services and the applications themselves. These packet transmissions continue even when the customer is not using the phone. Many mobile broadband networks experience an average of more than 400 packet calls or channel allocations per subscriber per day with the average data volume per allocation as low as 100 Kbytes (Ref: Based on live network measurements as described in the Nokia Networks white paper: "Smartphone Traffic Analysis and Solutions").

Nokia Smart Labs has analyzed smartphone behavior with an example illustrated in Figure 1.

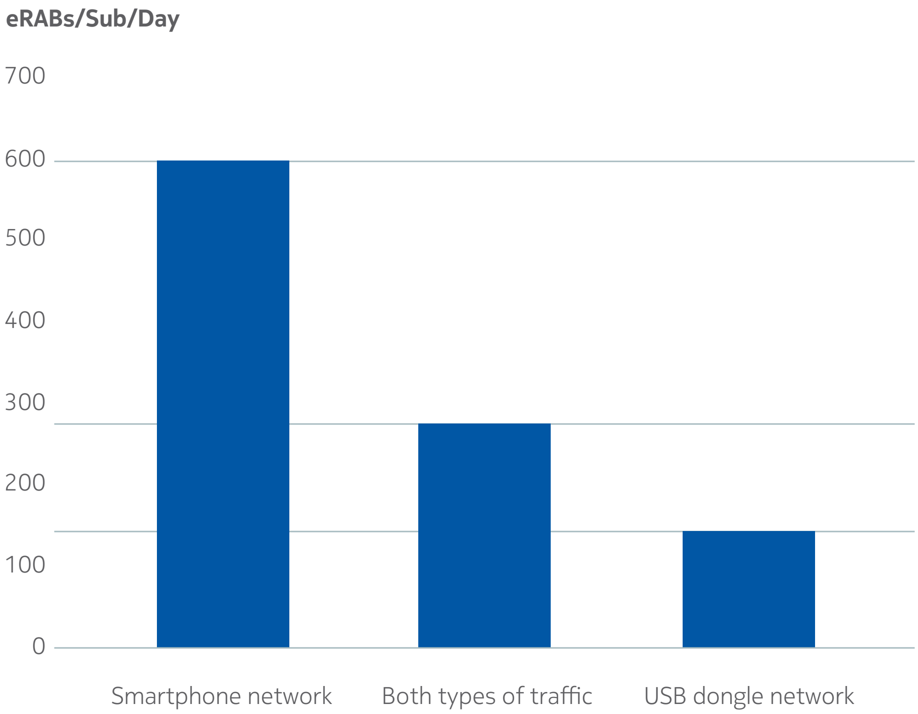

Figure. 1. Number of LTE packet calls (eRABs) per subscriber per day – network analysis

An Android-based smartphone creates two eRABs per hour simply due to the operating system, without any application activity. When popular social media applications (App A, App B and App C) are running in the background, the signaling activity increases to 17 eRABs per hour, equivalent to 400 per day as shown in Figure 2.

Average number of background LTE packet calls per hour

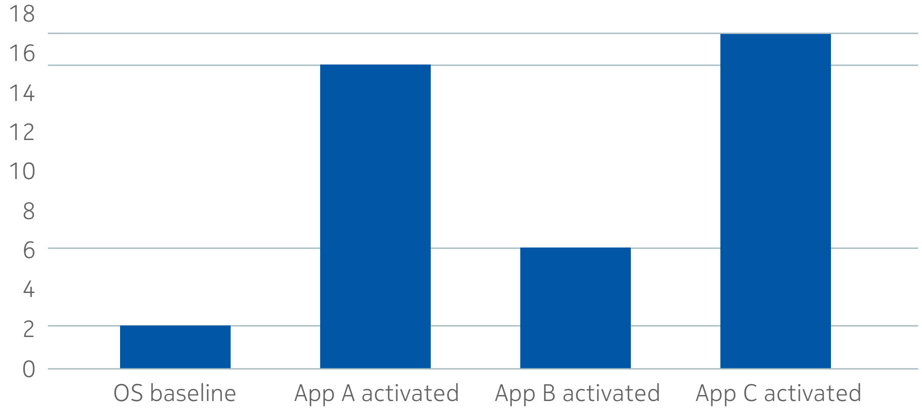

Figure. 2. Number of LTE packet calls (eRABs) per hour – Android-based smartphone analysis

WCDMA has lacked an effective channel to carry these medium-sized data packets. 3GPP Release 99 RACH/FACH is too slow, while HSPA requires not only heavy RRC signaling for allocation, but also takes more than three seconds to release the channel even though the transmission finishes within 10ms. This results in wasted capacity that could be used to carry revenue-generating user traffic. Furthermore, the battery life of devices is reduced as they remain in power consuming states longer than necessary.

To solve these issues, 3GPP Releases 7 and 8 introduced Enhanced Cell_FACH, which brings lower latency for user devices in the Cell_FACH state, not requiring high data volumes. This is achieved by reduced signaling and the use of high speed HSPA channels in DL and UL in the Cell_FACH state. Network signaling load is greatly reduced and fast transition from inactive to active provides an “always on” user experience. Additionally, Enhanced Cell_FACH includes Enhanced DRX, which allows inactive devices to turn off their reception to reduce battery consumption, waking intermittently to exchange short data bursts while in the Cell_FACH state. After a longer period of inactivity the device is commanded to enter Cell_PCH state, which saves even more battery power.

Nokia’s Enhanced Cell_FACH solution takes full advantage of the 3GPP feature and combined with the smart algorithms for inactivity detection, RRC state selection and Cell_PCH use, provides the best customer experience in terms of:

- high data rates in Cell_FACH
- real “always on” feeling
- fast state transitions from Cell_PCH to Cell_FACH (tens of milliseconds)

The solution also increases capacity and reduces signaling on smartphone-dominated networks.

Operators benefit through:

- Reduced signaling in the network
- Increased throughput
- More users supported
- Improvement of UL capacity

Operators can efficiently handle the small data packets that smartphones generate. Supporting the transmission of smaller packets on common HS-RACH and HS-FACH frees capacity for users on dedicated HSPA channels (better customer experience) and allows the system to offer the service for more smartphone users with faster set up and less signaling.

Live testing in a commercial network shows that end-users benefit from:

- 65% faster "response time" in IM applications like WhatsApp and Facebook Messenger
- 9-40% battery savings depending on the application in use
- 20% faster browsing
- 44% faster voice call set up

2. Enhanced Cell_FACH

2.1 Introduction

3GPP introduced Enhanced Cell_FACH in DL in Release 7. Enhanced Cell_FACH in UL and Enhanced DRX for UE in Cell_FACH were introduced in Release 8. These three features make up the complete Enhanced Cell_FACH (E-FACH), thus allowing HSPA networks to use the Cell_FACH state for smaller and medium size data packets while at same time bringing faster speeds, lower latency and battery savings for the user.

The downlink part of E-FACH is also called High Speed Cell_FACH DL, or HS-FACH, because it uses the HS-DSCH channel instead of the FACH channel in DL, while staying in the Cell_FACH state. Similarly, the uplink part of E-FACH is also called High Speed Cell_FACH UL, or HS-RACH due to the use of the E-DCH channel instead of the RACH channel in UL, while staying in the Cell_FACH state.

Enhanced Cell_FACH (E-FACH) feature in this document refers to High Speed FACH (HS-FACH), High Speed RACH (HS-RACH) and Enhanced DRX (eDRX) combined.

Enhanced Cell_FACH (E-FACH) state in this document refers to a UE in Cell_FACH state with HS-FACH in DL, HS-RACH in UL and eDRX configured.

Legacy Cell_FACH in this document refers to Release 99 Cell_FACH where UL transmission uses Release 99 RACH and the DL uses Release 99 FACH.

2.2 Benefits

As shown in Figure 3, compared to Release 6 HSPA where the UE has to first perform DCH setup signaling and then wait for several seconds while still consuming resources, with E-FACH, the UE can transmit data on HS-RACH using Common E-DCH resources provided by the network to transmit small and medium sized packets. This saves the HSPA resources in Cell_DCH which can then be used for larger data packets and traffic requiring such allocations.

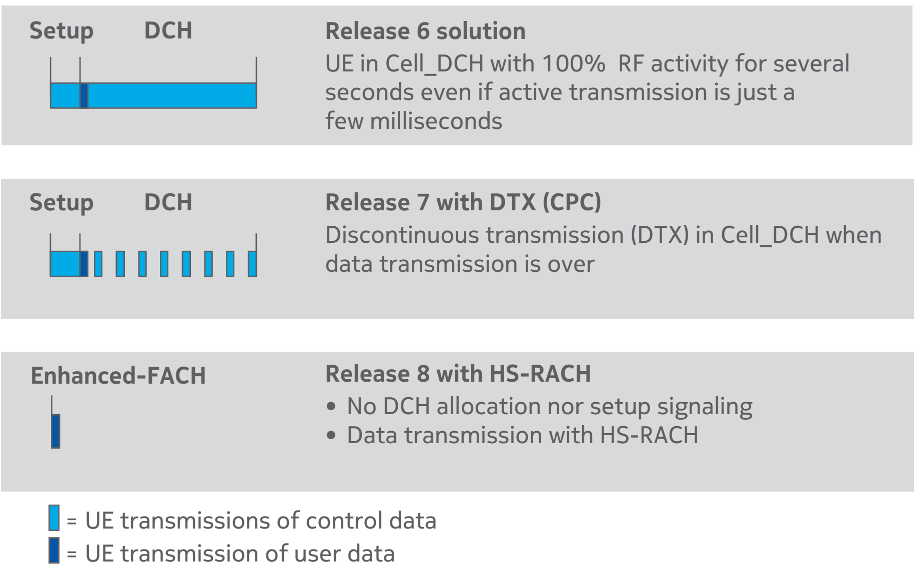

Figure. 3. Transmission of medium sized packet in HSPA networks

The overall benefit of the E-FACH is that it not only raises capacity and the performance for devices in Cell_FACH state but because of the use of HS-FACH in DL and HS-RACH in UL with Common E-DCH resources, the performance and state transition time from idle/Cell_PCH/URA_PCH to Cell_DCH/Cell_FACH improves.

Additionally, when a device in E-FACH state is moved to Cell_PCH state, a network can also keep the dedicated RNTIs allocated in Cell_PCH. This allows seamless transition from Cell_PCH to Cell_FACH state which improves the latency considerably when there is uplink or downlink activity, including packet data and voice calls. The UE moves to the “higher” state just by transmitting one RRC message instead of going through the Cell Update procedure signaling as required in the Release 99 Cell_FACH state.

Thus, E-FACH enables the network to keep users with bursty data in the Cell_FACH state and reduce the signaling load in the network for continuous state transitions.

Enhanced DRX in Cell_FACH supports discontinuous reception in the E-FACH state, thereby saving the UE's battery power, especially for applications requiring 'keep-alive' types of traffic. Low battery consumption enables the UE to stay in Cell_FACH for longer, resulting in a better customer experience with longer battery life and faster response times.

An additional advantage of this method is that the UE state transition from RX to DRX can be checked by the base station, and is not dependent on RNC inactivity timers.

Without Enhanced DRX, the UE continuously decodes all the downlink HS-SCCH frames in the Cell_FACH state. The Enhanced DRX operation determines when the UE is allowed to (discontinuously) receive HS-DSCH transmissions in Cell_FACH state. Thus, instead of decoding all the HS-SCCH frames, the UE will periodically read HS-SCCH frames at regular intervals. When data transmission starts in Enhanced Cell_FACH state, the UE interrupts the DRX operation.

As depicted in Figure 4, the DRX cycle includes:

- RX burst length: The duration in frames during which the UE reads HS-SCCH transmission
- DRX cycle length: Includes RX burst length and DRX cycle
- DRX cycle is the duration during which the UE will not read HS-SCCH frame

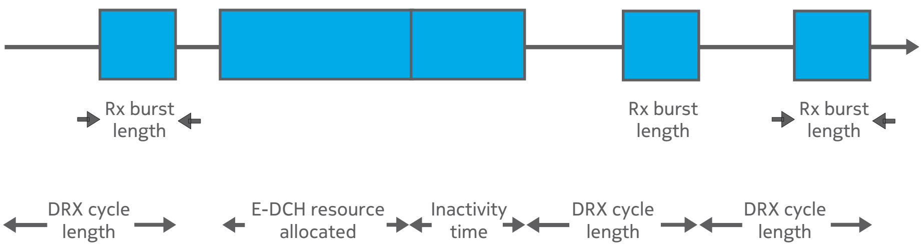

Figure. 4. Enhanced DRX mechanism

This enables the network to keep users with bursty data in the E-FACH state longer and reduce the signaling load in the network for continuous state transitions, while at the same time reducing device battery consumption.

Using Common E-DCH resources to transmit small and medium size packets allows a device to bypass the RRC signaling for DCH allocation and data is transmitted on HS-RACH. The reduced uplink control overhead lowers the noise rise in the uplink, allowing more bitrates for user data per Cell and more users per Cell.

As well as improved latency for small and medium size packets, voice call set-up time is also improved by 44% (Ref: Nokia Qualcomm joint test in a commercial network). This is attributed to the use of Common E-DCH resources in the E-FACH state, allowing faster transmission of smaller signaling messages in the uplink. Signaling overhead reduction and battery consumption reduction come from E-FACH due to the use of Enhanced DRX in Cell_FACH.

2.3 Gains from Cell_PCH state

When the UE in E-FACH states goes inactive, the network can move the UE to Cell_PCH with dedicated RNTIs i.e. C-RNTI, H-RNTI and E-RNTI. This allows the UE to perform seamless transition to E-FACH internally, bypassing the Cell Update procedure completely if the UE remains inactive in the same cell while in the Cell_PCH state. Thus it not only reduces the signaling for state transition from Cell_PCH to Cell_FACH, but also reduces the latency perceived by the end user.

Typically, smartphones remain in Cell_PCH to reduce their battery consumption. This also reduces the signaling required to enter "higher" states for further data transfer and thus reduces latency. With E-FACH and the use of dedicated RNTIs in Cell_PCH, further gains are achieved for CS voice calls starting from Cell_PCH, and for PS activity started while in Cell_PCH.

If the UE remains inactive in Cell_PCH longer and the network removes the dedicated RNTIs it, the UE will follow the legacy Cell Update signaling procedure to move to the Cell_FACH state. In this case, the UE still uses Enhanced Cell_FACH during the state transition procedure from Cell_PCH to Cell_FACH for sending small or medium size uplink packets, to initiate a CS call or to respond to paging.

If a UE in the Cell_PCH state has an originating or terminating voice call, while it also has dedicated RNTIs allocated in the cell, the CS call set up time improves considerably.

This is because the UE in Cell_PCH state, having dedicated RNTIs allocated (i.e. C-RNTI, H-RNTI and E-RNTI) can send an Initial Direct Transfer message directly, bypassing the Cell Update procedure from Cell_PCH. The signaling for call set up starts directly from the Cell_FACH state. While in the Cell_FACH state, the UE uses Common E-DCH resources for UL access and later continues signaling on HS-RACH in UL and HS-FACH in DL until it enters the Cell_DCH state with a call established.

3. Enhanced Cell_FACH in Nokia Test Network

Nokia and Qualcomm conducted a preliminary trial in the Nokia Test Network (NTN) at Espoo to evaluate the performance and user experience gains of the feature. The scope was to execute the Enhanced Cell_FACH Functional and KPI test cases in the field verification lab followed by the test network deployment in Otaniemi, Espoo.

The aim was to evaluate the feature functionality and project the KPI gains (mobile battery power savings, reduced signaling, etc.) from the Enhanced Cell_FACH feature set, with a defined set of real world applications like web browsing, ping and instant messaging. The tests were also performed under varying RF conditions and in several iterations.

The result showed considerable improvement in battery life, reduced signaling load and lowered latency (shorter delays) on the application as shown in Figure 5.

Ping

- 58% reduction in average Ping RTT
- 20% battery Savings
- 80% Signaling Reduction

Instant Messenger

- 50% Resource Efficiency
- 17% Battery Savings
- 81% Signaling Reduction
- 68% Faster Response Time

Web Browsing

- 33% Resource Efficiency
- 12% Signaling Reduction

Generic

- 51% Faster Channel Up-Switch
- 33% Faster CS call setup

* Best Case results indicated above

Figure. 5. E-FACH performance metrics from Nokia test network

The user experience of browsing was considerably better for Enhanced Cell_FACH users when the test UE spent more time in the Cell_FACH state. Furthermore, in the medium size ping test, despite the reference device being in Cell_DCH, the E-FACH user had better latency as shown in Figure 6.

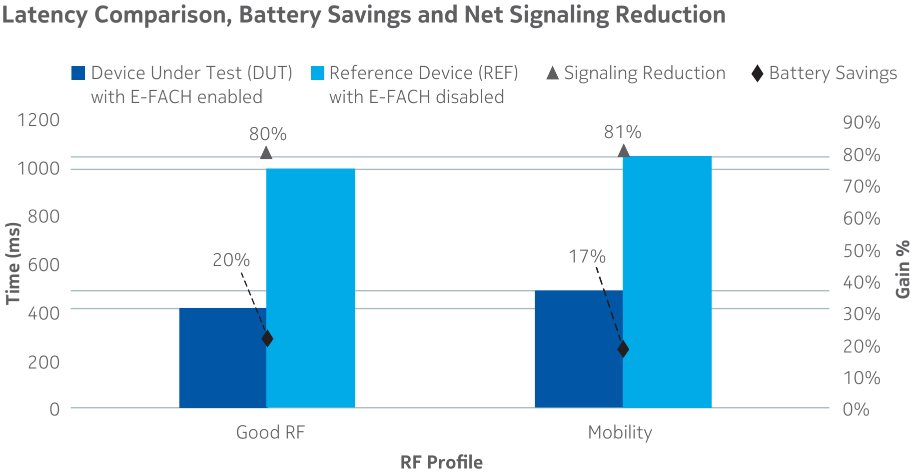

Figure. 6. Ping test

For the Instant Messenger test, "response time" was measured from the time the UE sends IM data out from its buffers to the time it receives TCP ACK, acknowledging the direct customer experience benefit. This response time was observed to be 68% faster for the Enhanced Cell_FACH user compared to the reference device as depicted in Figure 7. Enhanced Cell_FACH uses the Common EDCH resource to quickly send out data, while the legacy FACH user spends additional time transitioning to DCH before sending out the data.

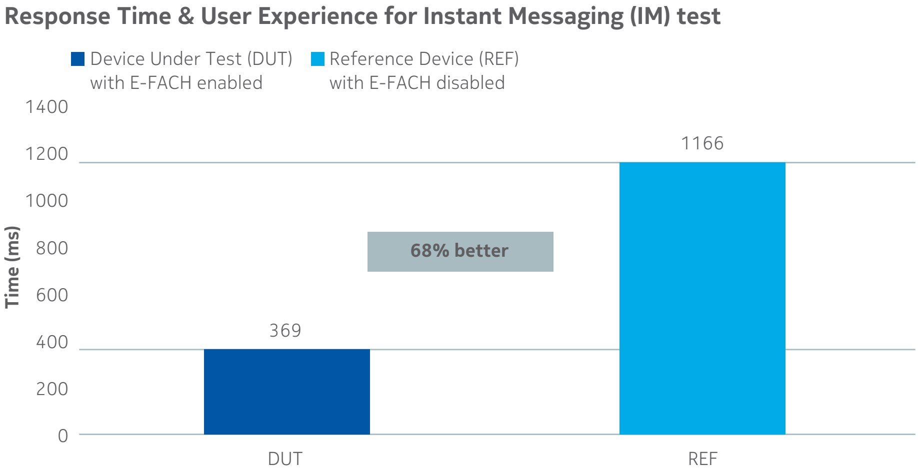

Figure. 7. IM test to measure the "response time"

Also, during the IM test, the Enhanced Cell_FACH user spent most of the time in Cell_FACH compared to the reference device as shown in Figure 8, thereby using the Common E-DCH resources. This enables it to save dedicated DCH resources for revenue-generating traffic. Additionally, when the Enhanced FACH user finished a transaction, it spent more time in Cell_PCH thus bringing additional battery saving, apart from the use of E-DRX in Cell_FACH.

RRC State Usage Comparison

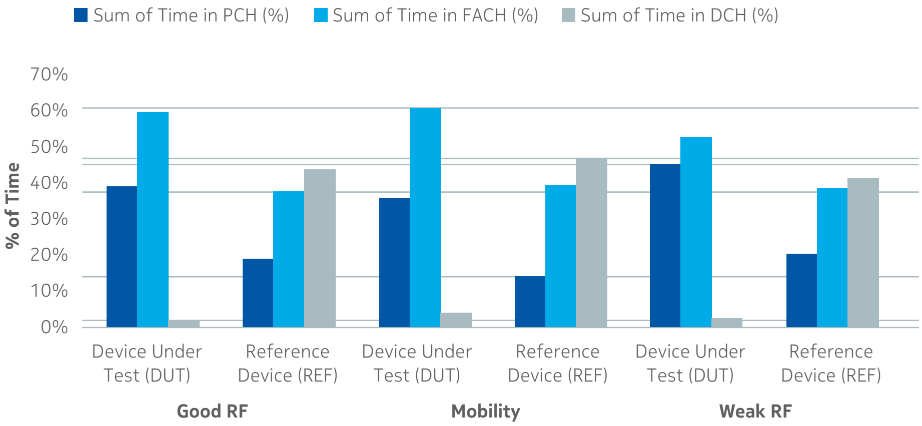

Figure. 8. RRC State usage comparison in IM test

4. Enhanced Cell_FACH in Commercial Network

Following the joint test by Nokia and Qualcomm in Nokia's Espoo test network, the feature was activated in a major operator's commercial network served by Nokia Networks. The scope of the test was to execute the E-FACH functional and KPI tests cases in a commercial network.

The aim of the trial was to measure the performance of the feature, measure the gains from E-FACH and its impact on the legacy devices and features deployed in the network.

The feature was activated in three sites inside one RNC area for a period of two weeks.

Note: In addition to the functional and KPI test cases, the performance of legacy commercial devices was also studied. Legacy commercial devices include those with early-release Enhanced Cell_FACH DL only, Enhanced Cell_FACH DL and UL and non-Enhanced Cell_FACH. It was crucial to both Nokia and Qualcomm to understand the impact of these devices separately from the performance of the feature itself on the latest device under test.

NW Software: RU50 RN8.0 + WN9.0

UE Software: Qualcomm MSM8974

The highlights of the results from the performance KPIs are shown in Figure 9

Ping
- 75% reduction in average Ping RTT
- 49.8% Battery Savings
- 87.2% Signaling Reduction

Instant Messenger
- 9% Battery Savings
- 81.8% Signaling Reduction
- 64.6% Faster Response Time

Web Browsing
- 13.2% Battery Savings
- 10.9% Signaling Reduction
- 20.8% Faster Browsing User Experience

Protocol Latency
- 66% Faster Channel Up-Switch
- 42% Faster Channel Up-Switch from MRM E4a to DCH
- 44% Faster CS call setup

* Best Case results indicated above

Figure. 9. E-FACH performance metrics from commercial network

RRC state usage analysis with a popular IM application revealed a saving in dedicated resource use as shown in Figure 10 when the Enhanced Cell_FACH user made use of Common E-DCH resources in the UL with about 65% faster response time.

User experience comparison

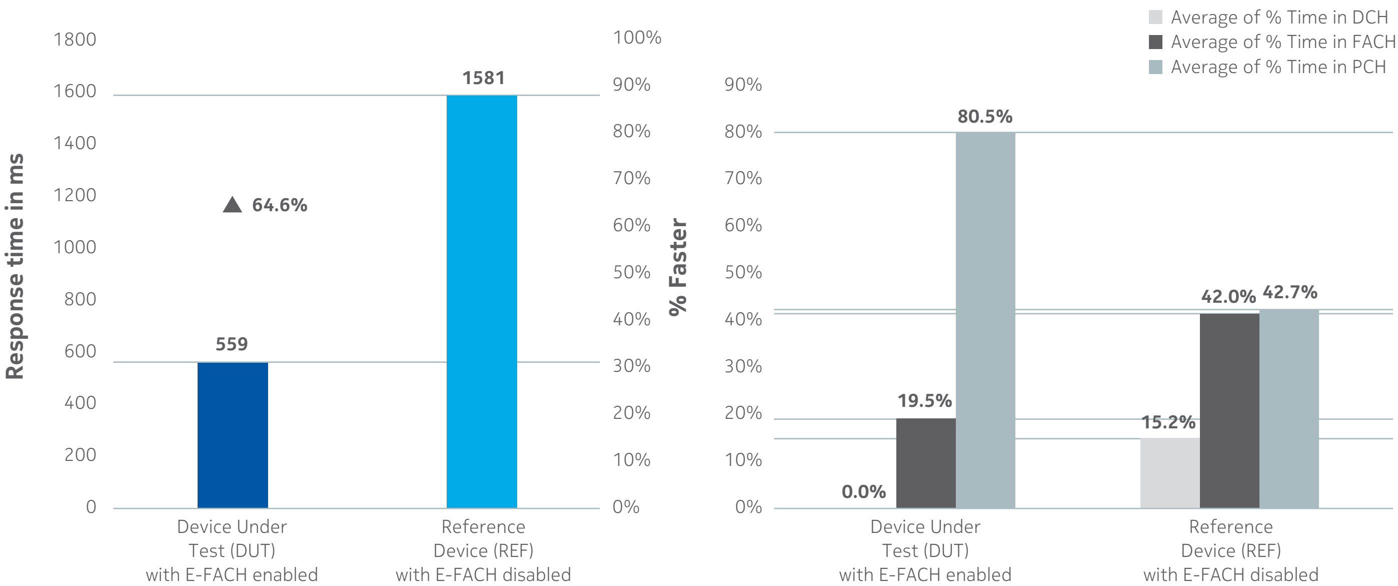

Figure. 10. User experience and resource usage efficiency during IM test

The commercial network trial showed no noticeable degradation in KPIs for non-Enhanced Cell_FACH users, due to the activation of Enhanced Cell_FACH in the network.

5. Conclusion

The Nokia Networks High Speed Cell_FACH feature includes the Enhanced Cell_FACH solution introduced in 3GPP Release 7 and Release 8, combining the High Speed Cell_FACH DL, High Speed Cell_FACH UL and Enhanced UE DRX in Cell_FACH.

The feature has been successfully tested in Nokia Smart Labs and jointly with Qualcomm in a Nokia Test Network and in a commercial network trial in Europe.

The Enhanced Cell_FACH feature helps operators to meet the demand of current smartphone-generated traffic involving small to medium size packets that trigger frequent state transitions to Cell_DCH.

The feature improves the customer experience in terms of latency of applications, faster voice call set up, faster up-switch time for applications requiring user to move to Cell_DCH and battery consumption.

The feature also reduces signaling in the network and provides more capacity to handle user traffic that helps to achieve a substantial gain in revenue generation.

6. Further reading

White papers

- Nokia Networks Smartphone Traffic Analysis and Solutions White Paper
  http://nsn.com/sites/default/files/document/nokia_smartphone_traffic_white_paper.pdf

Web pages

- Nokia Networks WCDMA/HSPA web page:
  http://nsn.com/portfolio/products/mobile-broadband/wcdmahspa
- Nokia Smart Labs web page:
  http://nsn.com/portfolio/solutions/smart-labs
- Qualcomm website:
  https://www.qualcomm.com/

7. Abbreviations

3GPP	3rd Generation Partnership Project
Cell_DCH	Cell Dedicated Channel (state of a UE)
Cell_FACH	Cell Forward Access Channel (state of a UE)
Cell_PCH	Cell Paging Channel (state of a UE)
C-RNTI	Common Radio Network Temporary Identity
CS	Circuit Switched
DL	Downlink
DPCCH	Dedicated Physical Control Channel
DRX	Discontinuous Reception
eDCH	Enhanced Dedicated Channel
eDRX	Enhanced Discontinuous Reception
eRAB	E-UTRAN Radio Access Bearer
E-RNTI	E-DCH Radio Network Temporary Identifier
FACH	Forward Access Channel
H-RNTI	HS-DSCH Radio Network Temporary Identifier
HS-FACH	High Speed Forward Access Channel
HSPA	High Speed Packet Access
HS-RACH	High Speed Random Access Channel
HS-SCCH	High Speed Shared Control Channel
IM	Instant Messenger
KPI	Key Performance Indicators
LTE	Long Term Evolution
PS	Packet Switched
RACH	Random Access Channel
RF	Radio Frequency
RNC	Radio Network Controller
RNTI	Radio Network Temporary Identity
RRC	Radio Resource Control (protocol)
RX	Reception
UE	User Equipment
UL	Uplink
URA_PCH	UTRAN Registration Area Paging Channel (state of a UE)

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